NATURAL GAMMA RADIATION -- NGR

Introduction

Gamma rays are electromagnetic waves with frequencies between 10^{19} and 10^{21} Hz. They are emitted spontaneously from an atomic nucleus during radioactive decay. Natural Gamma Radiation (NGR) measurements are used for three purposes: (1) correlation of core-to-core and core-downhole log; (2) evaluation of the clay/shale content of a formation; and (3) abundance estimates for radioisotopes K (potassium), Th (thorium), and U (uranium). Minerals that fix K, Th, and U, such as clay minerals, are the principal source of naturally-occurring gamma rays. Other earth materials that emit gamma rays include arkosic silt and sandstones, potassium salts, bituminous and alunitic schists, phosphates, certain carbonates, some coals, and acid or acido-basic igneous rocks.

The Ocean Drilling Program (ODP) installed a new NGR system on the MultiSensor Track (MST) during Leg 149, and began data collection on Leg 150. This represented a return of NGR data collection to scientific ocean drilling. The Deep Sea Drilling Project (DSDP) used a similar system early in its scientific program, but apparently removed the equipment because of the excessive time required to analyze cores. The early versions of the data acquisition program collected the spectral data in five energy windows compatible with the Schlumberger natural gamma downhole logging tool. After advancements in sensor efficiency and data acquisition technology allowed the downhole tools to acquire 256-channel spectral data, the MST NGR did also.

NGR Data Acquisition

In response to requests from the scientific community to address the need for additional capability to correlate cores between holes and integrate core and downhole logging data, the NGR system was added on the MST during Leg 149. There were four gamma-ray scintillation detectors mounted at 90^{o} angles from each other and in a plane orthogonal to the core track. Each scintillation counter contained a 3” x 3” doped sodium-iodide crystal and a photomultiplier to produce countable pulses. The detectors and sample chamber were mounted inside a lead housing recovered from the original NGR system used during DSDP.

The well–logging industry had used NGR logging tools for many years. Their reporting units were impractical for ODP use since the NGR apparatus could not be calibrated by the same method. For that reason, ODP NGR data are reported in cps (counts per second). This measurement unit was dependent on the device and volume of the material measured. Since one of the reasons for collecting NGR data was to facilitate the comparison of the core NGR data to downhole NGR logging data, the early versions of the data acquisition program collected the spectral data in five energy windows compatible with the downhole tools. These windows were:

- Window 1: 0.2 – 0.5 MeV (million electron volts)
- Window 2: 0.5 – 1.1 MeV
- Window 3: 1.1—1.59 MeV
- Window 4: 1.59 – 2.0 MeV
- Window 5: 2.0 – 3.0 MeV

A major MST upgrade during Leg 169 implemented the change to collecting and reporting the full 256-channel data. This was a major improvement, but in order to use NGR data for spectral analysis to determine elemental abundances of K, Th and U, significantly longer counting times would be required. Data acquisition hardware continued to improve and made it possible to do either longer counts or higher density of measurements, but not both. Also, with the need to keep the core moving through the MST, especially on legs with high core recovery, data acquisition speeds had not yet reached a point where it was practical to sample long enough for spectral analysis. Data analysis indicated there was a problem with the higher channels of the detectors; during Leg 189, the software was changed to only report 248 channels of data.

Table 1. NGR systems.

Legs	Equipment	Comments
149 – 150	MST Track – NGR	NGR added to track
151 – 162	MST Track – NGR	Leg 151 – Software upgrade
163 – 169 (Site 1036)	MST Track – NGR	Major software upgrade installed Leg 163 Port Call
169 (Site 1037) – 187	MST Track – NGR	Major software upgrade – 256-channel counts reported. Leg 171 Janus database operational.
188 – 210	MST Track – NGR	Minor software changes during this time. Leg 189 – implemented change where only 248 of the channels reported. (See text for explanation).

Standard Operating Procedures

By the time NGR was added to the MST, procedures for analyzing sections were well established. After the cores were brought to the Physical Properties Laboratory, they were stored on a rack to allow them to equilibrate to room temperature before analyzing them on the MST (MSL and PWL measurements are sensitive to the temperature of the core). A zero background measurement would normally be taken once a day to check on potential contamination within the laboratory. (See discussion of background under Data Quality section.) Because of the need to count for a longer period of time to get more accurate measurements, the sample interval was often set to 20 or 30 cm. As data acquisition hardware and software improved, a higher density sampling could be done without decreasing the counting period significantly, but ODP did not reach the goal of routinely collecting high quality spectral data that could be used for elemental abundance.

Calibration

The four scintillation counters must be tuned to return the same signal level for each emission energy. Amplification signals may drift so the counters were adjusted at the beginning of each leg. After the counters were tuned, an energy calibration was performed. Potassium and thorium standards were measured and a linear regression returned the calibration coefficients that convert channel numbers to energy intervals. A full discussion of the NGR system and calibration procedures can be found in *Technical Note 26: Physical Properties Handbook,* Chapter 5 (Blum, 1997).

Archive

Pre-Janus Archive

Most of the original NGR data files were archived on the ODP/TAMU servers. There was no interim database for these data. In a few instances, the files for a hole were concatenated into a single file. Some of these original files are no longer available, either because the scientists who concatenated the hole file deleted them, or they were not moved onto the ODP/TAMU servers.

Migration of NGR data to Janus

The data model for NGR Natural Gamma Radiation can be found in Appendix I. Included are the relational diagram and the list of the tables that contain data pertinent to NGR, the column names, and the definition of each column attribute. ODP Information Services Database Group was responsible for the migration of pre-Leg 171 data to Janus. The migration of NGR was done in conjunction with the other MST datasets – GRA Bulk Density estimation, Magnetic Susceptibility Logger, and P-Wave Logger. Each change in format was documented and added to the MST Migration program. Additional information about the migration of NGR data or original file formats can be requested from the IODP Data Librarian.

The structure of the NGR data tables were revised a couple times before the version in use at the end of ODP. Initially, the 256-channel spectral counts were stored in an NGR_SPECTRA_DATA table (described in the Physical Properties Handbook). This table structure rapidly became unusable. Instead, the spectral data were concatenated into a large text field that could be downloaded and the spectral counts extracted. The migration of the older NGR data had already been started with a table being created to store the counts in the energy windows. It was decided not to reformat those data into the same field as the 256-channel data.

Janus NGR Data Format

The NGR data can be retrieved from Janus Web using a predefined query. The Natural Gamma Radiation query webpage allows the user to extract data using the following variables to restrict the amount of data retrieved: leg, site, hole, core, section, specific run numbers, depth range, or latitude and longitude range. In addition, the user can use the Output Raw Data option in the query to extract information relating to the core status, run parameters, and calibration data used to calculate the Total Counts and Background-corrected Counts. There is also the Display Spectra option that will extract the spectra collected at each sample location. There are over one million NGR data records in Janus.

Table 2 lists the data fields retrieved from the Janus database for the predefined NGR query with Output Raw Data and Display Spectra options turned on. The first column contains the data item; the second column indicates the Janus table or tables in which the data were stored; the third column is the Janus column name or the calculation used to produce the value. Appendix II contains additional information about the fields retrieved using the Janus Web NGR query, and the data format for the archived ASCII files.

Table 2. Natural Gamma Radiation query with Output Raw Data and Display spectra options

Item Name	Janus Table	Janus Column Name and Calculation
Leg	SECTION	Leg
Site	SECTION	Site
Hole	SECTION	Hole
Core	SECTION	Core
Type	SECTION	Core_type
Section	SECTION	Section_number
Top (cm)	NGR_SECTION_DATA	MST_Top_Interval x 100
Depth (mbsf)	DEPTH_MAP, NGR_SECTION_DATA	DEPTH_MAP.Map_Interval_Top + NGR_SECTION_DATA.MST_top_interval
Bkg.-Corrected Counts (cps)	NGR_SECTION_DATA NGR_BACKGROUND	NGR_SECTION_DATA.total_counts_sec – NGR_BACKGROUND.total_counts_sec
Uncorrected Total Counts (cps)	NGR_SECTION_DATA	NGR_SECTION_DATA.total_counts_sec
Background Counts (cps)	NGR_BACKGROUND	Total_counts_sec
Run Number	NGR_SECTION	Run_Number
Run Date/Time	NGR_SECTION	Run_Date_Time (mm-dd-yyyy hh:mi:ss)
Core Status	NGR_SECTION	Core_Status
Liner Status	NGR_SECTION	Liner_Status
Requested Interval	NGR_SECTION	Requested_DAQ_Interval
Requested Period (s)	NGR_SECTION	Requested_DAQ_Period
Actual Period (s)	NGR_SECTION_DATA	Actual_DAQ_Period
Core Diameter (cm)	NGR_SECTION_DATA	Core_diameter
Calib. Date/Time	NGR_CALIBRATION	Calibration_Date_Time (mm-dd-yyyy hh:mi:ss)
Calib. Intercept (keV)	NGR_CALIBRATION	Channel_energy_M0
Calib. Slope (keV)	NGR_CALIBRATION	Channel_energy_M1
Calib Error (mse)	NGR_CALIBRATION	Channel_energy_mse
Energy Windows	NGR_SECTION_DATA	**Legs 150-169 Site 1036:** Energy_windows **Legs 169 Site 1037 – 210:** [not used]
First Channel	NGR_SECTION_DATA	**Legs 150-169 Site 1036:** [not used] **Legs 169 Site 1037 – 210:** NGR_first_channel
Last Channel	NGR_SECTION_DATA	**Legs 150-169 Site 1036:** [not used] **Legs 169 Site 1037 – 210:** NGR_last_channel
Channel Increment	NGR_SECTION_DATA	**Legs 150-169 Site 1036:** [not used] **Legs 169 Site 1037 – 210:** NGR_channel_increment
Spectra	NGR_ENERGY_WINDOWS NGR_SECTION_DATA	**Legs 150-169 Site 1036:** NGR_counts_sec **Legs 169 Site 1037 – 210:** NGR_spectra

Data Quality

There are several factors that affect the quality of NGR measurements, including background radiation, sampling period and sample spacing, tool response -- detector efficiency and energy response, sample volume and operational characteristics.

Background. Zero background is gamma radiation detected in the measurement area when no core material is present. Background measurements were done by measuring a core liner filled with distilled water. The background spectrum could then be subtracted from each sample spectrum. Studies over several years show that background values were relatively constant at 8 – 9 cps. A daily control measurement was done to check for potential contamination.

Sampling period and sample spacing. Counting statistics play an important role in the measurement of radioactive phenomena which are random and discrete. A longer time period at a sample location will give a better estimation of the amount of radioactive elements (K, Th and U). For ODP purposes, this meant that there had to be a balance between longer counting periods and density of sampling. Because of the other sensors on the MST, high density sampling and long counting periods were not usually possible. The ODP average total count rate was about 30 cps. With a sampling period of 30 s, the statistical error would be ~3%, which gave data good enough for core-to-core correlations.

Tool response. NGR measurements are dependent upon the sensitivity or efficiency of the system to detect when a gamma ray has been emitted. The sodium iodide crystals emit a single photon of light after being struck by a gamma ray. The photon then strikes a photocathode which releases a burst of electrons. The electrons are accelerated and a final electrode conducts a current through a resistor to produce the voltage pulse. Low detector efficiency or undetected electrical signals result in lower counts.

Sample volume. Radiation counts are directly proportional to the volume of material. Hydraulic piston coring (APC, coretype H) used to recover softer, undisturbed sediments will routinely give the best results because the core liner is usually full. However, the sediments can also contain a lot of gas which will create voids in the cored material. Cores cut by XCB and RCB are often biscuits surrounded by drilling mud or irregularly-shaped pieces. Voids, smaller diameter core, irregular pieces, thin runny mud will all result in less volume per measurement interval. Table 3 below summarizes how much of each core type was analyzed for natural-occurring gamma radiation.

Table 3: NGR Analysis Statistics

	Core Recovery	NGR Analyzed	Percent
APC – coretype H	113,999 meters	47,696 meters	41.8 %
XCB – coretype X	61,638 meters	27,915 meters	45.3 %
RCB – coretype R	45,869 meters	22,019 meters	48.0 %
TOTAL	222,429 meters	97,705 meters	43.9 %

Operations. The core sections were most often run through the MST system before the liners were opened and the core curated. During the curation process, core material was often shifted. In sedimentary cores, voids may have been closed. Gassy cores may have small voids that continue to enlarge after analysis. Sections may not be completely full, and material may have spread throughout the liner. After curation, this material was shoved up to close voids and the section's curated length was less than what was originally analyzed. The effects can be seen when looking at the data for a section: 1) there are reasonable values beyond the curated length of the section (null depth values); 2) there are lower values at an interval compared with adjacent measurements and GRA density values are low indicating less volume.

Hard rock cores can be continuous cylinders with consistent diameter or can be broken into small irregular pieces. The curation process shifts hard rock pieces, sometimes even shifting core material from its original liner section to an adjacent section liner. Where the core material was in its liner during analysis and where it was eventually placed after curation can be very different. NGR data for these types of cores should be used with caution.

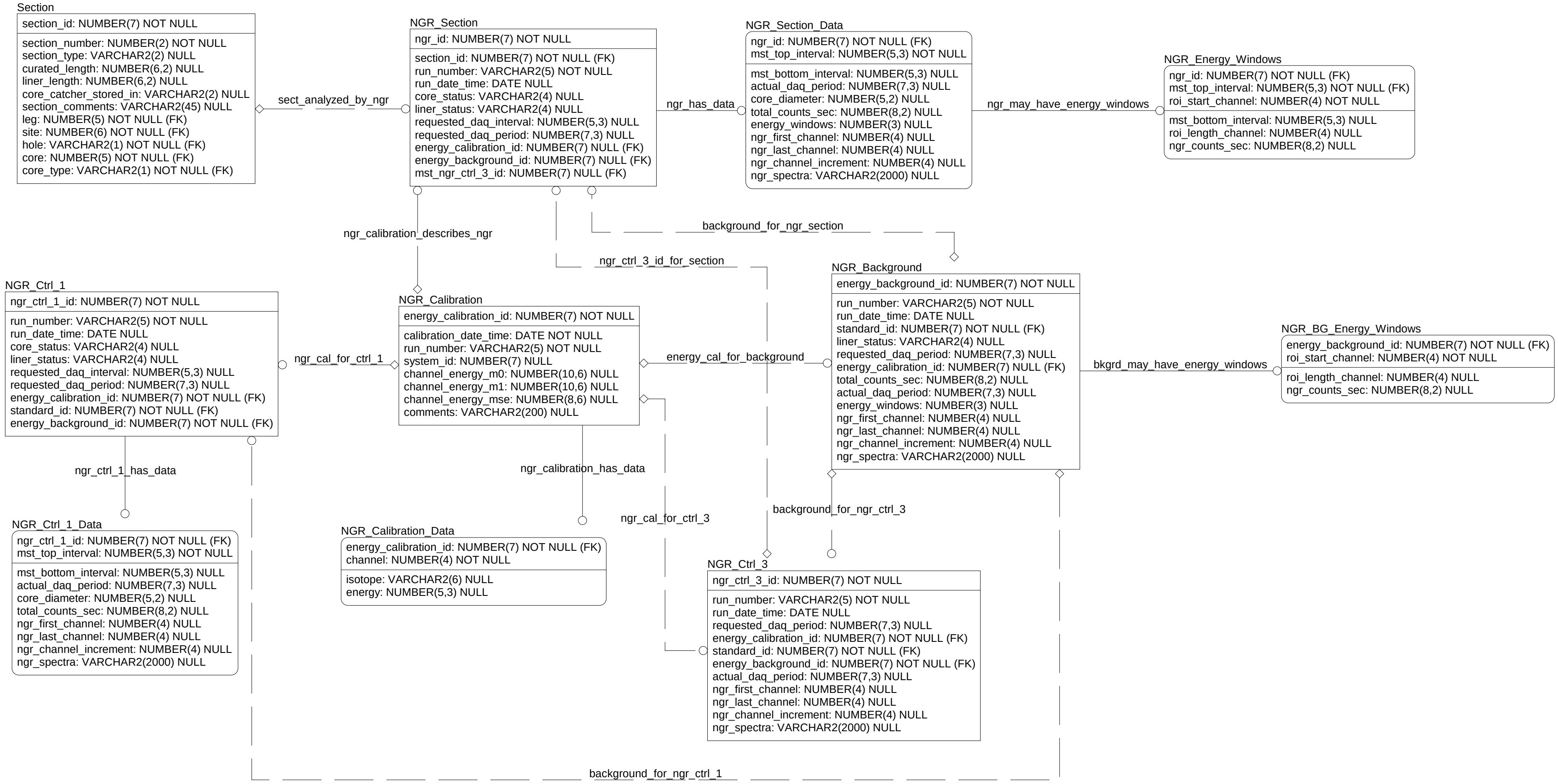
One more important factor that needs to be considered is operator error. Throughout the ODP, the operator manually entered core information into the data acquisition program. Typographical errors or typing in the wrong data occasionally happened, and some mistakes were not identified. Sometimes, the scientific party noticed the error and corrected it for the data included in the Initial Report volume, but the original files did not get corrected. A lot of effort during verification of the migrated NGR data has gone into finding sections that may have been misidentified. Some runs have been renamed to different sections. The evidence for misidentification had to be conclusive. Listed below are some of the clues used to find incorrectly identified analyses:

- two runs for a given section, no run for the following section;
- run numbers out of sequence;
- two runs for a section, run numbers out of sequence - no data for that core and section in a different hole, but sequence of run numbers would be correct;
- Nature of the core material – length of core, voids or less than full liners.

References

Blum, P., 1997, Physical Properties Handbook: A guide to the shipboard measurement of physical properties of deep-sea cores, ODP Tech. Note 26.

Hoppie, B.W., Blum, P., et al., 1994, 5. Natural Gamma-Ray Measurements on ODP Cores: Introduction to Procedures with Examples from Leg 150. *In* Mountain, G.S., Miller, K.G., Blum, P., et al., *Proc. ODP, Init. Repts*., 150: College Station, TX (Ocean Drilling Program), 51 – 59.


Section
section_id: NUMBER(7) NOT NULL
section_number: NUMBER(2) NOT NULL
section_type: VARCHAR2(2) NULL
curated_length: NUMBER(6,2) NULL
liner_length: NUMBER(6,2) NULL
core_catcher_stored_in: VARCHAR2(2) NULL
section_comments: VARCHAR2(45) NULL
leg: NUMBER(5) NOT NULL (FK)
site: NUMBER(6) NOT NULL (FK)
hole: VARCHAR2(1) NOT NULL (FK)
core: NUMBER(5) NOT NULL (FK)
core_type: VARCHAR2(1) NOT NULL (FK)
sect_analyzed_by_ngr
NGR_Section
ngr_id: NUMBER(7) NOT NULL
section_id: NUMBER(7) NOT NULL (FK)
run_number: VARCHAR2(5) NOT NULL
run_date_time: DATE NULL
core_status: VARCHAR2(4) NULL
liner_status: VARCHAR2(4) NULL
requested_daq_interval: NUMBER(5,3) NULL
requested_daq_period: NUMBER(7,3) NULL
energy_calibration_id: NUMBER(7) NULL (FK)
energy_background_id: NUMBER(7) NULL (FK)
mst_ngr_ctrl_3_id: NUMBER(7) NULL (FK)
ngr_has_data
NGR_Section_Data
ngr_id: NUMBER(7) NOT NULL (FK)
mst_top_interval: NUMBER(5,3) NOT NULL
mst_bottom_interval: NUMBER(5,3) NULL
actual_daq_period: NUMBER(7,3) NULL
core_diameter: NUMBER(5,2) NULL
total_counts_sec: NUMBER(8,2) NULL
energy_windows: NUMBER(3) NULL
ngr_first_channel: NUMBER(4) NULL
ngr_last_channel: NUMBER(4) NULL
ngr_channel_increment: NUMBER(4) NULL
ngr_spectra: VARCHAR2(2000) NULL
ngr_may_have_energy_windows
NGR_Energy_Windows
ngr_id: NUMBER(7) NOT NULL (FK)
mst_top_interval: NUMBER(5,3) NOT NULL (FK)
roi_start_channel: NUMBER(4) NOT NULL
mst_bottom_interval: NUMBER(5,3) NULL
roi_length_channel: NUMBER(4) NULL
ngr_counts_sec: NUMBER(8,2) NULL
ngr_calibration_describes_ngr
background_for_ngr_section
ngr_ctrl_3_id_for_section
NGR_Ctrl_1
ngr_ctrl_1_id: NUMBER(7) NOT NULL
run_number: VARCHAR2(5) NOT NULL
run_date_time: DATE NULL
core_status: VARCHAR2(4) NULL
liner_status: VARCHAR2(4) NULL
requested_daq_interval: NUMBER(5,3) NULL
requested_daq_period: NUMBER(7,3) NULL
energy_calibration_id: NUMBER(7) NOT NULL (FK)
standard_id: NUMBER(7) NOT NULL (FK)
energy_background_id: NUMBER(7) NOT NULL (FK)
ngr_cal_for_ctrl_1
NGR_Calibration
energy_calibration_id: NUMBER(7) NOT NULL
calibration_date_time: DATE NOT NULL
run_number: VARCHAR2(5) NOT NULL
system_id: NUMBER(7) NULL
channel_energy_m0: NUMBER(10,6) NULL
channel_energy_m1: NUMBER(10,6) NULL
channel_energy_mse: NUMBER(8,6) NULL
comments: VARCHAR2(200) NULL
energy_cal_for_background
NGR_Background
energy_background_id: NUMBER(7) NOT NULL
run_number: VARCHAR2(5) NOT NULL
run_date_time: DATE NULL
standard_id: NUMBER(7) NOT NULL (FK)
liner_status: VARCHAR2(4) NULL
requested_daq_period: NUMBER(7,3) NULL
energy_calibration_id: NUMBER(7) NULL (FK)
total_counts_sec: NUMBER(8,2) NULL
actual_daq_period: NUMBER(7,3) NULL
energy_windows: NUMBER(3) NULL
ngr_first_channel: NUMBER(4) NULL
ngr_last_channel: NUMBER(4) NULL
ngr_channel_increment: NUMBER(4) NULL
ngr_spectra: VARCHAR2(2000) NULL
bkgrd_may_have_energy_windows
NGR_BG_Energy_Windows
energy_background_id: NUMBER(7) NOT NULL (FK)
roi_start_channel: NUMBER(4) NOT NULL
roi_length_channel: NUMBER(4) NULL
ngr_counts_sec: NUMBER(8,2) NULL
ngr_ctrl_1_has_data
ngr_calibration_has_data
ngr_cal_for_ctrl_3
background_for_ngr_ctrl_3
NGR_Ctrl_1_Data
ngr_ctrl_1_id: NUMBER(7) NOT NULL (FK)
mst_top_interval: NUMBER(5,3) NOT NULL
mst_bottom_interval: NUMBER(5,3) NULL
actual_daq_period: NUMBER(7,3) NULL
core_diameter: NUMBER(5,2) NULL
total_counts_sec: NUMBER(8,2) NULL
ngr_first_channel: NUMBER(4) NULL
ngr_last_channel: NUMBER(4) NULL
ngr_channel_increment: NUMBER(4) NULL
ngr_spectra: VARCHAR2(2000) NULL
NGR_Calibration_Data
energy_calibration_id: NUMBER(7) NOT NULL (FK)
channel: NUMBER(4) NOT NULL
isotope: VARCHAR2(6) NULL
energy: NUMBER(5,3) NULL
NGR_Ctrl_3
ngr_ctrl_3_id: NUMBER(7) NOT NULL
run_number: VARCHAR2(5) NOT NULL
run_date_time: DATE NULL
requested_daq_period: NUMBER(7,3) NULL
energy_calibration_id: NUMBER(7) NOT NULL (FK)
standard_id: NUMBER(7) NOT NULL (FK)
energy_background_id: NUMBER(7) NOT NULL (FK)
actual_daq_period: NUMBER(7,3) NULL
ngr_first_channel: NUMBER(4) NULL
ngr_last_channel: NUMBER(4) NULL
ngr_channel_increment: NUMBER(4) NULL
ngr_spectra: VARCHAR2(2000) NULL
background_for_ngr_ctrl_1

APPENDIX I: Janus Data Model – Natural Gamma Radiation – NGR

Natural Gamma Radiation - NGR		
Table Name	**Column Name**	**Column Comment**
NGR_Section	ngr_id	Unique Oracle-generated sequence number for each NGR analysis run.
	section_id	Unique Oracle-generated sequence number to identify each section.
	run_number	Number identifying a run generated by the data acquisition software. This number is not used to identify the run in Janus because it may not be unique.
	run_date_time	Timestamp when analysis was run.
	core_status	Indicates if a full or half (split) core is being analyzed. Valid values are FULL or HALF.
	liner_status	Records if a core liner was used, a split liner or no liner. Valid values are FULL, HALF and NONE.
	requested_daq_interval	The data acquisition interval requested for section analysis in cm
	requested_daq_period	The data acquisition period requested in seconds
	energy_calibration_id	Unique Oracle-generated sequence number for NGR calibration runs.
	energy_background_id	Unique Oracle-generated sequence number for NGR background runs.
	mst_ngr_ctrl_3_id	Unique Oracle-generated sequence identifier for NGR control-3 runs.

NGR_Section_Data	ngr_id	Unique Oracle-generated sequence number for each NGR analysis run.
	mst_top_interval	Top interval of a measurement in meters measured from the top of a section
	mst_bottom_interval	Bottom interval of a measurement in meters measured from the top of a section
	actual_daq_period	Actual data acquisition period used for measurements, in seconds.
	core_diameter	Diameter of core in cm
	total_counts_sec	The total combined counts per second of the NGR spectrum.
	energy_windows	Flag to indicate when spectral data are found in NGR_Energy_Windows table.
	ngr_first_channel	First natural gamma ray channel number for which the spectrum value is stored in the ngr_spectra.
	ngr_last_channel	Last natural gamma ray channel number for which the spectrum value is stored in the ngr_spectra.
	ngr_channel_increment	Channel number increment
	ngr_spectra	NGR spectra for the channels defined by first, last, increment.

NGR_Background	energy_background_id	Unique Oracle-generated sequence number for natural gamma background runs.
	run_number	Number identifying a run generated by the data acquisition software. This number is not used to identify the run in Janus because it may not be unique.
	run_date_time	Timestamp when analysis was run.
	standard_id	Unique identifier for a physical properties standard.
	liner_status	Records if a core liner was used, a split liner or no liner. Valid values are FULL, HALF and NONE.
	requested_daq_period	The data acquisition period requested in seconds
	energy_calibration_id	Unique Oracle-generated sequence number for NGR calibration runs.
	total_counts_sec	The total combined counts per second of the NGR spectrum.
	actual_daq_period	Actual data acquisition period used for measurements, in seconds.
	energy_windows	Flag to indicate when spectral data are found in NGR_Energy_Windows table.
	ngr_first_channel	First natural gamma ray channel number for which the spectrum value is stored in the ngr_spectra.
	ngr_last_channel	Last natural gamma ray channel number for which the spectrum value is stored in the ngr_spectra.
	ngr_channel_increment	Channel number increment
	ngr_spectra	NGR spectra for the channels defined by first, last, increment.

Natural Gamma Radiation - NGR

Table Name	Column Name	Column Comment
NGR_Calibration	energy_calibration_id	Unique Oracle-generated sequence number for NGR calibration runs.
	calibration_date_time	Timestamp when calibration was run.
	run_number	Number identifying a run generated by the data acquisition software. This number is not used to identify the run in Janus because it may not be unique.
	system_id	Unique identifier for a system of equipment on the ship.
	channel_energy_m0	Calibration intercept m0
	channel_energy_m1	Calibration slope m1.
	channel_energy_mse	Calibration mean squared error
	comments	General comments about the calibration run.

NGR_Calibration_Data	energy_calibration_id	Unique Oracle-generated sequence number for NGR calibration runs.
	channel	Channel number
	isotope	Characteristic isotope emitting at peak (for example K-40)
	energy	Energy of emission at peak

NGR_Ctrl_1	ngr_ctrl_1_id	Unique Oracle-generated sequence identifier for NGR control-1 runs, used to compare a sample run to a control-1 run.
	run_number	Number identifying a run generated by the data acquisition software. This number is not used to identify the run in Janus because it may not be unique.
	run_date_time	Timestamp when analysis was run.
	core_status	Indicates whether a whole or half (split) core is being analyzed. Valid values are FULL or HALF.
	liner_status	Records if a core liner was used, a split liner or no liner. Valid values are FULL, HALF and NONE.
	requested_daq_interval	Requested data acquisition interval for section analysis in cm
	requested_daq_period	Requested data acquisition period in seconds.
	energy_calibration_id	Unique Oracle-generated sequence number for NGR calibration runs.
	standard_id	Unique identifier for a physical properties standard.
	energy_background_id	Unique Oracle-generated sequence number for NGR background runs.

NGR_Ctrl_1_Data	ngr_ctrl_1_id	Unique Oracle-generated sequence identifier for NGR control-1 runs, used to compare a sample run to a control-1 run.
	mst_top_interval	Top interval of a measurement in meters measured from the top of a section
	mst_bottom_interval	Bottom interval of a measurement in meters measured from the top of a section
	actual_daq_period	Actual data acquisition period used for measurements, in seconds.
	core_diameter	Diameter of core in cm
	total_counts_sec	The total combined counts per second of the NGR spectrum.
	ngr_first_channel	First natural gamma ray channel number for which the spectrum value is stored in the ngr_spectra.
	ngr_last_channel	Last natural gamma ray channel number for which the spectrum value is stored in the ngr_spectra.
	ngr_channel_increment	Channel number increment
	ngr_spectra	NGR spectra for the channels defined by first, last, increment.

NGR_Ctrl_3	ngr_ctrl_3_id	Unique Oracle-generated sequence identifier for NGR control-3 runs, used to associate a sample run to a control-3 run.
	run_number	Number identifying a run generated by the data acquisition software. This number is not used to identify the run in Janus because it may not be unique.
	run_date_time	Timestamp when analysis was run.
	requested_daq_period	The data acquisition period requested in seconds
	energy_calibration_id	Unique Oracle-generated sequence number for NGR calibration runs.
	standard_id	Unique identifier for a physical properties standard.

Natural Gamma Radiation - NGR

Table Name	Column Name	Column Comment
	energy_background_id	Unique Oracle-generated sequence number for NGR background runs.
	actual_daq_period	Actual data acquisition period used for measurements, in seconds.
	ngr_first_channel	First NGR channel number for which the spectrum value is stored in the ngr_spectra.
	ngr_last_channel	Last NGR channel number for which the spectrum value is stored in the ngr_spectra.
	ngr_channel_increment	Channel number increment
	ngr_spectra	NGR spectra for the channels defined by first, last, increment."
NGR_Energy_Windows	ngr_id	Unique Oracle-generated sequence number for each NGR analysis run.
	mst_top_interval	Top interval of a measurement in meters measured from the top of a section.
	roi_start_channel	First channel of the region of interest (ROI).
	mst_bottom_interval	Bottom interval of a measurement in meters measured from the top of a section.
	roi_length_channel	Length of the channel including the first channel.
	ngr_counts_sec	NGR counts per sec measured in the energy window specified by roi_start_channel and roi_length_channel
NGR_BG_Energy_ Windows	energy_background_id	Unique Oracle-generated sequence number for NGR background runs.
	roi_start_channel	First channel of the region of interest (ROI).
	roi_length_channel	Length of the channel including the first channel.
	ngr_counts_sec	NGR counts measured per sec in the energy window specified by roi_start_channel and roi_length_channel.
Section	section_id	Unique Oracle-generated sequence number to identify each section. This is done because of the physical subsection / zero section problems. In adding new sections, deleting sections or changing sections - don't want to have to renumber.
	leg	Number identifying the cruise for which data were entered into the database.
	site	Number identifying the site from which the core was retrieved. A site is the position of a beacon around which holes are drilled.
	hole	Letter identifying the hole at a site from which a core was retrieved or data were collected.
	Core	Sequential numbers identifying the cores retrieved from a particular hole. Cores are generally 9.5 meters in length, and are numbered serially from the top of the hole downward.
	core_type	A letter code identifying the drill bit/coring method used to retrieve the core.
	section_number	Cores are cut into 1.5 m sections. Sections are numbered serially, with Section 1 at the top of the core.
	section_type	Used to differentiate sections of core (S) from core catchers (C). Previously, core catchers were stored as section CC, but in Janus core catchers are given the next sequential number from the last section recovered.
	curated_length	The length of the section core material, in meters. This may be different than the liner length for the same section. Hard rock cores will often have spacers added to prevent rock pieces from damaging each other.
	liner_length	The original length of core material in the section, in meters. Sum of liner lengths of all the sections of a core equals core recovery.
	core_catcher_stored_in	Sometimes the core catcher is stored in a D tube with a section. core_catcher_stored_in contains the section number of the D tube that holds the core catcher.
	section_comments	Comments about this section.

Appendix II: Description of data items from NGR query.

Column Name	Column Description	Format
Leg	Number identifying the cruise. The ODP started numbering the scientific cruises of the *JR* at Leg 101. A leg was nominally two months duration. During the 18+ years of the ODP, there were 110 cruises on the *JR*.	Integer 3
Site	Number identifying the site. A site is the location where one or more holes were drilled while the ship was positioned over a single acoustic beacon. The *JR* visited 656 unique sites during the course of the ODP. Some sites were visited multiple times, including some sites originally visited during the Deep Sea Drilling Program for a total of 673 site visits.	Integer 4
Hole	Letter identifying the hole. Multiple holes could be drilled at a single site by pulling the drill pipe above the seafloor, moving the ship some distance away and drilling another hole. The first hole was designated 'A' and additional holes proceeded alphabetically at a given site. Location information for the cruise was determined by hole latitude and longitude. During ODP, there were 1818 holes drilled or deepened.	Text 1
Core	Cores are numbered serially from the top of the hole downward. Cored intervals are up to 9.7 m long, the maximum length of the core barrel. Recovered material was placed at the top of the cored interval, even when recovery was less than 100%. More than 220 km of core were recovered by the ODP.	Integer 3
Type	All cores are tagged by a letter code that identifies the coring method used.	Text 1
Section	Cores are cut into 1.5 m sections in order to make them easier to handle. Sections are numbered serially, with Section 1 at the top of the core. NGR measurements were made on sections. Core Catcher sections identified as "CC".	Integer 2 (Text 2)
Top (cm)	The top interval of a measurement in centimeters measured from the top of a section.	Decimal F6.1
Depth (mbsf)	Distance in meters from the seafloor to the sample location.	Decimal F13.3
Bkg.-Corrected Counts (cps)	The total combined counts per second of the NGR spectrum with the background counts subtracted.	Decimal F13.2
Uncorrected Total Counts (cps)	The total combined counts per second of the NGR spectrum.	Decimal F13.2
Background Counts (cps)	The total combined counts per second of the NGR spectrum of the background (no core material).	Decimal F13.2
Run Number	Number generated by the data acquisition software, to identify an analysis run of a section of core.	Text 6
Run Date/Time	Timestamp identifying when analysis was run.	Text 16 (yyyy-mm-dd hh:mi)
Core Status	Indicates whether a whole or half (split) core is being analyzed. Valid values are FULL or HALF.	Text 12
Liner Status	Records if a core liner was used, a split liner or no liner. Valid values are FULL, HALF and NONE.	Text13
Requested Interval	Requested sampling interval, in centimeters.	Decimal 14.2
Requested Period (s)	The requested data acquisition period in seconds.	Decimal 12.2
Actual Period (s)	The actual data acquisition period in seconds.	Decimal 12.2
Core Diameter (cm)	Diameter of the core in centimeters.	Decimal 15.1

Column Name	Column Description	Format
Calib. Date/Time	Timestamp when calibration was run.	Text 16 (yyyy-mm-dd hh:mi)
Calib. Intercept (keV)	Calibration intercept m0.	Decimal F17.3
Calib. Slope (keV)	Calibration slope m1.	Decimal F13.3
Calib Error (mse)	Calibration mean squared error.	Decimal F17.3
Energy Windows	**Legs 150-169 Site 1036:** Energy_windows **Legs 169 Site 1037 – 210:** [not used]	Integer 3
First Channel	**Legs 150-169 Site 1036:** [not used] **Legs 169 Site 1037 – 210:** NGR_first_channel	Integer 8
Last Channel	**Legs 150-169 Site 1036:** [not used] **Legs 169 Site 1037 – 210:** NGR_last_channe	Integer 9
Channel Increment	**Legs 150-169 Site 1036:** [not used] **Legs 169 Site 1037 – 210:** NGR_channel_increment	Integer 9
Spectra	**Legs 150-169 Site 1036:** NGR_counts_sec – 5 [cps (energy Kev – energy Kev)]. Example: *515(80-344) 141(346-741) 31(880-1060) 12(1104-1280) 4(1600-1800)* **Legs 169 Site 1037 – 210:** NGR_spectra – 256 Integer 4	Text 2000